IS 10178 (1995): CO2 gas shielded metal arc welding of structural steels - Recommendations [MTD 12: Welding Applications]

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भारतीय मानक

संरचना इस्पात की कार्बन-डाइ-ऑक्साइड गैस परिरक्षित आर्क-वेल्डिंग — सिफारिशें

(पहला पुनरीक्षण)

Indian Standard

CO_2 GAS SHIELDED METAL-ARC WELDING OF STRUCTURAL STEELS — RECOMMENDATIONS

(First Revision)

ICS 25·160·10 : 77·080·10

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

November 1995

Price Group 5

Arc Welding Applications and Thermal Cutting Sectional Committee, MTD 12

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Arc Welding Applications and Thermal Cutting Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1981. While reviewing the standard in the light of experience gained during these years, the Committee decided to revise it to bring it in line with the present practices being followed by the Indian Industry.

The CO_2 gas shielded metal-arc welding is becoming increasingly popular in the fabrication of boilers, pressure vessels, ship's hull, etc. This standard has been prepared as a guide to the industry, dealing with the theoretical and practical aspects of the process.

In this revision, following changes have been made:

a) Electrode extension values have been modified,

b) Typical melting rates have been modified, and

c) Details of welding processes through high current techniques have been modified.

While formulating this standard, necessary assistance has also been derived from the following publications:

CO_2 Welding of steel. The Welding Institute, Abington, UK.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CO_2 GAS SHIELDED METAL-ARC WELDING OF STRUCTURAL STEELS — RECOMMENDATIONS

(*First Revision*)

1 SCOPE

This standard covers recommendations on equipment, consumables, general procedure and technique for semi-automatic and automatic carbon dioxide gas shielded metal arc welding of weldable structural steels, including tubes and hollow sections.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
307 : 1966	Carbon dioxide (*second revision*)
812 : 1957	Glossary of terms relating to welding and cutting of metals
1030 : 1989	Carbon steel castings for general engineering purposes (*fourth revision*)
2002 : 1992	Steel plates for pressure vessels for intermediate and high temperature service including boilers (*third revision*)
2062 : 1992	Steel for general structural Purposes (*fourth revision*)
3600 (Part 1) : 1995	Cruciform fillet well tensile test (*second revision*)
6419 : 1971	Welding rods and bare electrodes for gas shielded arc welding of structural steel
6560 : 1972	Molybdenum and chromium molybdenum low alloy steel welding rods and base electrodes for gas shielded arc welding

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 812 :1957 shall apply.

4 PARENT METAL

This standard applies to CO_2 gas shielded metal-arc welding including overlaying of weldable quality structural steels conforming to IS 2062 : 1992, IS 1030 : 1989, IS 2002 : 1992 and similar steels.

5 WELDING CONSUMABLES

5.1 The bare wire electrodes shall conform to IS 6419 : 1971, and IS 6560 : 1972 as appropriate.

5.2 Carbon dioxide gas shall conform to IS 307 : 1966.

6 EQUIPMENT

6.1 Power Source

The CO_2 gas shielded arc welding process is influenced by the static load characteristic and the dynamic properties of power source. Only welding generators or rectifiers having flat to slightly drooping V-A characteristics and good dynamic properties are suitable. For better monitoring of welding parameter, the power source shall incorporate voltmeter and ammeter.

6.2 Wire Feed Unit

6.2.1 The wire feed unit consists of a feed motor, sets of feed and drive rollers and wire guiding arrangement. The feed rates vary from 2 to 10 m/min. It shall have proper speed regulator to give uniform and smooth feed almost without inertia, from wire reel to the welding gun and to the welding zone. As it controls the welding current, this aspect is more important when higher range of feed rates are used. The unit shall have suitable starting and stopping controls and an inching switch.

6.2.2 For welding thin sheets, the wire feeding device may be incorporated into the welding gun itself enabling uniform wire feeding even with extremely thin wire and producing uniform quality welds. It shall be light enough to be manoeuvred by the operator without fatigue in semi-automatic welding.

6.3 The Welding Gun

The welding gun shall have 'Start'–'Stop' switch and ensure uniform transport of wire. A hollow cable consisting of a wire-spiral leads the wire electrode from feed rollers to the gun. One current terminal is connected to the contact nozzle through which passes the electrode. The contact nozzle is surrounded by a gas nozzle, which shall emit flow of shielding gas between the nozzle and the surface of the parent metal without turbulance. The gun is mounted on the travelling carriage in automatic welding.

6.3.1 The welding gun may either be gas cooled or water cooled. The guns should be rated adequately for the intended continuous intermittent use within permissible temperature limits of usage.

NOTE — Air cooling is generally sufficient up to 400 A. Above 400 A water cooling is necessary especially for automatic welding (100 percent duty cycle).

6.4 Mains and Control Unit

Main unit shall consist of a protective transformer and a rectifier to supply current to the control unit. It may be incorporated in the rectifier power source itself or may be a separate unit in case of generators. The protective transformer is required for safety and to enable welding work on boilers and tanks.

6.4.1 The control unit contains all controlling and switching elements, the pressure operated switch for cooling water (if used), solenoid valve for releasing CO_2 gas during the welding processes and other controls like timers for spot welding and automatic welding processes. The wire feed unit is generally coupled with it. The wire feed regulator is also housed in it.

6.5 Instruments and Ancillary Equipment

The flow rate of CO_2 gas should be adequate to obtain a clean weld. This depends on several factors such as welding current, welding speed, electrode diameter joint geometry and local conditions. It generally varies from 15 to 22 litres/min.

6.5.1 A suitable gas flow-meter is mounted just after the pressure regulator and gas heater. Generally CO_2 gas is drawn from cylinders and the heater shall be able to prevent CO_2 ice formation due to gas expansion. The flow meter should give direct flow-rate readings for CO_2 gas in litres/min and should have proper protective covering against breakage.

6.5.2 The cooling device for water cooled welding gun, consists of a pump with motor, a water tank and a heat exchanger. For gas cooled torches shielding gas itself will cool the torch.

6.5.3 The wire feed unit along with the control unit and the welding gun are mounted on a travelling carriage in case of automatic welding. The travelling speed of carriage shall be infinitely regulable within the welding speed range.

7 ELECTRODE EXTENSION

7.1 The free end protruding out of contact nozzle carries high current densities (over 100 A/mm^2). An increase in this length results in the increase of melting rates. However, the arc-current falls with increase in the protruding length. This is particularly noticeable when welding in deep grooves where a narrow joint preparation limits the access of the nozzle. Excessive protruding length will, therefore, lead to lack of penetration unless special techniques are used as in narrow-gas welding.

7.2 Recommended values of electrode extension are given below for various current levels:

Current A	*Electrode Extension* mm
50 - 150	10-13
150 - 350	13-18
350 - 400	18-21

7.3 Recommended nozzle to work distance for various current levels are given below:

Current A	*Nozzle to Work Distance* mm
50 - 150	13
150 - 350	15
350 - 400	18

8 POLARITY

The electrode is generally connected to positive pole. Only in cases such as overlaying, negative pole is connected to the electrode in order to take advantage of higher melting rates and low penetration.

9 JOINT PREPARATION

9.1 Due to deep penetration, special edge preparation for thin plates is not required. For example, with a 1.6 mm diameter electrode, 12 mm thick plates can be welding with square butt joint (with a joint gap of 3 mm) from both sides at a welding current of 330 to 370 A axial spray transfer technique. With thicker plates or thinner electrodes it is sufficient to have a steep V-joint with an included angle of 30 to 40°.

9.2 When preparation of the fusion faces is necessary this shall be done by shearing, chipping, machining, gas-cutting or any other method provided the requirements of **9.3** are complied with.

9.3 Fusion Faces

9.3.1 Fusion faces shall be smooth and free from slag, lamination, notches or other irregularities which might be the cause of defects or would affect adversely the quality of weld and the workmanship.

9.3.2 Fusion faces and the surfaces adjacent to the joint for a distance of at least 50 mm on either side of the joint shall be free from heavy scale, moisture, oil, paint or any other substance which might affect the quality of the weld or impede the progress of welding.

9.4 Typical details of joint are given in Tables 1 to 4.

10 WELDING POSITION

It is possible to weld all types of joints in all welding position by CO_2 gas welding process. For difficult positions like vertical and overhead welding, electrodes up to 1.2 mm diameter with lower welding voltage (19-23V) and current (50-155A) are used.

11 BACKING AND FIT-UP

If backing strips are not to be used, tolerance on root gaps and alignment of parts should be maintained closely to control penetration. Typical details of joints are given in Tables 1 to 4.

Table 1 Typical Welding Conditions For Butt Joints in the Flat Position (Manual)

(*Clauses* 9.4, 11, 14.1 *and* 14.2)

Material Thick-ness	Wire Diameter	Welding Current	Arc Voltage	Wire Feed Rate	Welding Speed	No. of Passes	Joint Pre-paration	Root Face	Root Gap	Remarks
mm	mm	A	V	mm/min	mm/min			mm	mm	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	0.8	60	18	2 500	450	1	SCB	—	—	—
1.6	0.8	80	18	3 400	600	1	SCB	—	—	—
3	0.8	120	20	5 500	450	1	SEOB	—	0.8	—
	1.2	140	20	3 000	600	1	SEOB	—	0.8	—
6	1.2	150	20	3 250	350	2	SSV-40°	—	—	—
	1.2	350	32	12 500	450	1	*SEOB	—	0.8	HCT
10	1.2	150	20	3 250	250	3	SSV-40°	—	0.8	—
	1.6	370	32	5 000	350	1	*SSV-30°	—	1.5	—
20	1.2	350	32	12 500	250	3	DSV-40°	3	—	HCT
	1.6	430	34	6 300	250	3	DSV-40°	3	—	HCT
40	1.6	430	34	6 300	250-350	7	DSV-40°	3	—	HCT
75	1.6	430	34	6 300	250-350	26	DSV-40°	3	—	HCT

SCB – Square close butt
SEOB – Square edge open butt
SSV – Single side V
DSV – Double side V
*Backing strip
HCT – High current technique

NOTE — Refer 6.5 for gas flow rates.

Table 2 Typical Welding Conditions for Butt Joints in the Vertical Position (Manual)

(*Clauses* 9.4, 11, 14.1 *and* 14.3)

Material Thickness	Wire Diameter	Welding Current	Arc Voltage	Wire Feed Rate	Welding Speed	No. of Passes	Joint Preparation	Root Face	Root Gap
mm	mm	A	V	mm/min	mm/min			mm	mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	0.8	60	18	2 500	450	1D	SCB	—	—
1.6	0.8	80	18	3 400	600	1D	SCB	—	—
3	0.8	120	20	5 500	450	1D	SEOB	—	1.5
6	1.2	150	20	3 250	250	2D	SSV-60°	—	1.5
10	1.2	150	20	3 250	150	3U	SSV-60°	—	1.5
20	1.2	150	20	3 250	150	4U	SSV-60°	—	1.5
	1.6	160	22	1 900	150	4U	DSV-60°	—	1.5
40	1.2	150	20	3 250	120	7U	DSV-60°	—	1.5
	1.6	160	22	1 900	120	7U	DSV-60°	—	1.5
75	1.6	160	22	1 900	80	25U	DSV-60°	—	1.5

SCB – Square close butt
SEOB – Square edge open butt
DSV – Double side V
SSV – Single side V
D – Vertical down
U – Vertical up

NOTE — Refer 6.5 for gas flow rates.

Table 3 Typical Welding Conditions for Butt Joints in Flat Position (Automatic)
(*Clauses* 9.4, 11, 14.1 *and* 14.4.2)

Material Thick-ness	Wire Diameter	Welding Current	Arc Voltage	Wire Feed Rate	Welding Speed	No. of Passes	Joint Pre-paration	Root Face	Root Gap	Remarks
mm	mm	A	V	mm/min	mm/min			mm	mm	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	1	105	20	3 250	1300	1	SCB	—	—	—
2	1	135	20	4 500	800	1	SEOB	—	0.8	—
3	1	165	22	5 900	650	1	SEOB	—	1.5	—
6	1.6	350	32	5 300	360	1	*SCB	—	—	—
10	1.6	350	32	5 300	200	2	SCB	—	—	—
					180	2	*SSV-30°	—	1.5	—
20	1.6	430	34	6 300	150	2	DSV-30°	6	—	HCT
35	2.0	700	42	5 600	100	4	DSV-50°	6	—	HCT
					120					
50	2.0	750	46	6 000	80	6	DSU-10°	10	—	HCT
					150			RR-6		

SCB – Square close butt
SEOB – Square edge open butt
SSV – Single side V
DSV – Double side V
DSU – Double side U
RR – Root radius
HCT – High current technique
* Backing strip

NOTE — Refer 6.5 for gas flow rates.

12 TACKING

Tack welds shall be made as frequently and as small as possible, yet large enough to withstand the welding stresses without cracking. The tacking technique should avoid a lumpy cold start. The unfilled craters can be avoided by back tracing. Tacking is generally done with a short circuiting arc since all positional welding conditions are required.

13 WELDING PROCESS

13.1 In CO_2 welding, metal transfer in general, takes place under short circuits. It is in the form of small drops for electrodes up to 1.2 mm diameter and in the form of coarse drops for electrodes over 1.2 mm diameter. In both the cases the drop transfer frequency increases with the increase of welding current. There also exists a critical current above which the metal transfer takes place in fine drops without making short circuits. This critical current value, of course, is appreciable higher than that in the MIG-Welding process. An increase of voltage makes the drop transfer coarser. The loss of alloying elements of electrode is less when welding is done with thinner wires and lower arc voltages that is for fine drop transfer. This is due to shorter reaction time of drop with the oxygen in arc atmosphere. As such lower arc voltages of 20 to 30 V are recommended. The welding current is selected so as to give current densities between 100 and 200 A/mm^2 of the electrode. Such high current densities result in higher melting rates.

Table 4 Typical Welding Conditions for Fillet Welds in Flat Position
(*Clauses* 9.4, 11 *and* 14.1)

Fillet Size Leg Length	Wire Diameter	Welding Current	Arc Voltage	Wire Feed Rate	Welding Speed	No. of Passes
mm	mm	A	V	mm/min	mm/min	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2	0.8	60	18	3 000	420	1
3	0.8	155	21	10 000	640	1
	1.0	180	24	6 500	760	1
	1.2	150	21	4 000	480	1
6	0.8	115	20	6 500	130	2
	1.0	140	22	4 800	150	1
	1.2	180	24	5 000	200	1
10	0.8	155	21	10 000	90	2
	1.0	230	26	9 400	140	2
	1.2	270	31	8 600	160	1
	1.6	350	32	5 300	180	1
20	1.2	170	21	4 700	25	4
	1.2	300	35	10 000	50	3
	1.6	270	26	3 600	40	3
	1.6	350	32	5 300	50	2
25	1.2	170	21	4 700	20	9
	1.2	300	35	10 000	40	6
	1.6	270	26	3 600	20	8
	1.6	250	32	5 300	25	4

NOTE — Refer **6.5** for gas flow rates.

Typical melting rates are given in Table 5.

Table 5 Melting Rates
(*Clause* 13.1)

Electrode Diameter mm	Current A	Melting Rate kg/h
(1)	(2)	(3)
0.8	50 -180	0.5 - 2.8
1.0	70 - 225	0.75 - 3.5
1.2	80 - 270	1.0 - 5.2
1.6	160 - 400	1.7 - 9.2
2.0	220 - 475	2.5 - 10.0

13.1.1 Depending on the critical current for a particular electrode diameter two types of techniques are identified:

a) Short-arc technique, and
b) High-current technique.

13.2 Short-Arc Technique

In this technique, the metal transfer taken place in a certain cyclic manner, which is reinforced through a corresponding modification of power sources.

13.2.1 By conventional arc welding process, it is difficult to weld sheets of thickness less than 3 mm. Because of longer arcing time between the individual short circuits (heating time), under usual arc welding conditions the metal at the end of the consumable electrode reaches boiling temperature. This results in higher heat inputs in the parent metal leading to deeper fusion penetration and corresponding bigger weld pool in case of thinner sheets because of slower heat dissipation by the parent metal. In short arc process, the overheating of the consumable electrode end, the excess heat input in the parent metal is prevented by reducing the heating time. This is achieved by modification of short-circuiting process through shortening of arc.

13.2.2 This requires a dc set with flat to slightly drooping static characteristic. An additional inductance or choke is required to limit the short circuit current to improve the dynamic characteristics.

13.2.3 When the metal transfer takes place with short circuits the electrode end dips in the weld pool. The short circuit is broken by the factors which are also responsible in other processes. After opening of short circuit an arc of higher current is produced. Due to its higher pressure a crater is formed in the weld pool. The breaking of short circuit causes the inductance to build up a back e.m.f. due to which the welding current and voltage decrease. It results in reduction of the arc-pressure on the weld pool decreasing thereby the crater depth. This means the distance between the electrode and the weld pool surfaces (arc length) is reduced. The melting rate is also reduced with the fall of current, thereby breaking the equilibrium between the melting rate and the wire feed. The electrode end, therefore, approaches the weld pool. The arc length is, thus reduced faster till the electrode again comes in contact with the weld pool.

13.2.4 These short-circuits take place at a rate of 100 to 200 times per second. For the stability of this special melting process, the static characteristics of the dc source and the value of inductance play a major role. The value of inductance should correspond correctly to the electrode diameter, welding current and the electrode extension. Generally 0.8, 1.0 and 1.2 mm diameter electrodes with current densities of 100 to 200 A/mm^2 are used in this process.

13.3 High Current Technique

In this CO_2 gas welding process the electrode carries current in the range of 300 A per mm of diameter of wire. This results in better productivity because of higher melting rates and increased fusion penetration. The spatter loss is also reduced. Generally 1.2, 1.6 and 2.0 mm diameter electrode are used in this process.

13.3.1 The higher current densities affect the mode of metal transfer. Above critical current, which, for example, is 350 A for 1.2 mm diameter electrode and 450 A for 1.6 mm diameter electrode, the metal transfer is in small drops at higher frequency and without short circuits. However, the typical spray-type mode of drop transfer encountered in MIG-welding is not reached in this process.

13.3.2 In this technique, the heating times of drops at the electrode end is less because of higher drop-frequency. As such the loss of alloying elements is lower, although due to higher currents, higher voltages are to be used.

13.3.3 The high-current technique brings more advantages in welding of thicker plates (higher melting rate and deeper penetration) and in overlaying (high melting rate, less loss of alloying elements). The disadvantages are bigger weld-reinforcements and to some extent poor weld appearance.

13.4 Recommended current voltage combination for various wire diameters are given in Fig. 1.

13.5 CO_2 Spot Welding

The welding pistol is so designed that the shielding gas nozzle can sit properly on the parent metal surface and withstand the necessary holding force.

Generally 1.6 mm diameter electrode are used. The arc is established after switching on the wire feed by short circuiting the electrode with the parent metal. The current density varies from 120 to 200 A/mm^2. The welding time controlled by time varies from 0.8 to 2.0 sec.

14 WELDING PARAMETERS

14.1 Recommendations are given for power source up to 750 A in Tables 1 to 4. For automatic welding heavy duty machines are necessary as welding can be done at much higher speeds than those obtained with semi-automatic operation. These tables may be used to make other joints with slight changes in the parameters.

14.2 Downhand Welding

Typical parameters are given in Table 1. Some data, as indicated, refer to high-current technique.

14.3 Vertical Welding

In Table 2 typical welding conditions are given for vertical welding. Sheets in vertical position are normally welded in vertically down position as it gives better control over penetration. In making butt welds the root run is normally deposited without weaving to avoid over-penetration. For thicker plates, it is better to weave into the root and to use a 50° V or U preparation to get better access to the joint.

14.4 Automatic Welding

14.4.1 CO_2 gas metal-arc welding lends itself well to mechanization. Certain welds such as edge welds and outside corner cannot be effectively made by manual welding; whereas they could be made satisfactorily by mechanized CO_2 gas metal arc welding. This is due to the precision with which the arc can be directed with machine control.

14.4.2 In mechanized welding there is considerable increase in welding speeds. Sheet size material can be welded at a speed of 2 500 mm/min. Typical conditions are given in Table 3.

14.4.3 Excessive welding speed result in undercutting although this can be improved by welding with a slope.

At high currents the weld bead shape may be improved by welding in tilted of flat position. Arc voltages may also be used to improve the reinforcement shape of butt joints made by mechanized welding.

15 WELD DEFECTS AND THEIR CAUSE

The weld defects that may occur in CO_2 gas shielded metal-arc welding and the causes for these defects are also given in Table 6.

16 TESTING

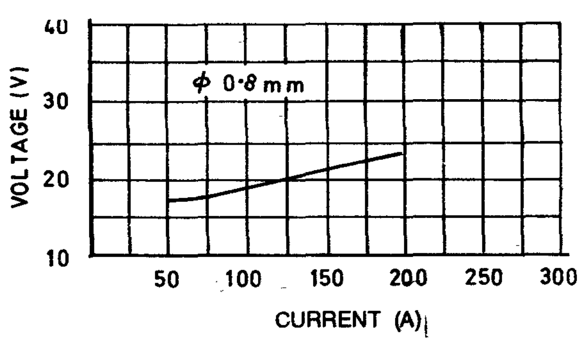
16.1 Tests to be carried out depend upon the service requirements of the components to be welded and shall be as specified in relevant application standard, or in the absence of such a standard, as agreed to between the contracting parties.

16.2 Methods of testing the welded joints shall be according to IS 3600 (Part 1) : 1985. Split plate tests shall be carried out to test the welding procedure and parameters in case of spot welding.

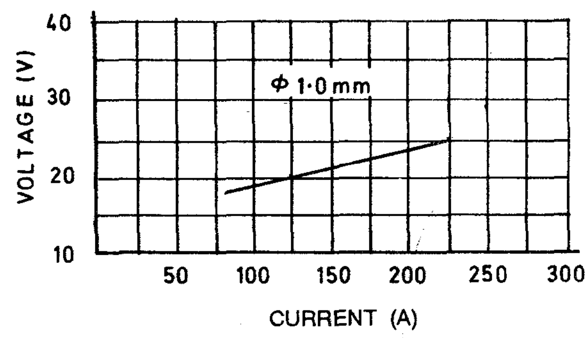
16.3 NDT testing shall be carried out as per the agreement between the contracting parties.

17 HEALTH AND SAFETY

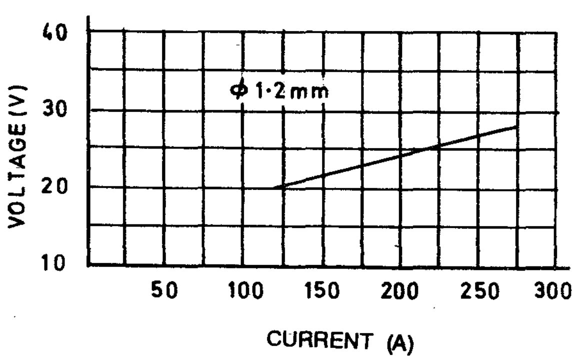
As CO_2 gas is heavier than air, care should be taken to arrange for proper exhaust and ventilation when welding is done in confined space. In the arc, CO_2 breaks down into carbon monoxide (CO) but this gas generally recombines with atmospheric oxygen at the edge of the arc and only a small amount exists outside the arc zone. The hygenic safety limit lies at 0.01 percent or 100 ppm for CO and 5 000 ppm for CO_2. There is no risk of CO poisoning at any point beyond 300 mm from the nozzle. Because of the intense heat from the arc, it is not possible for an operator to get close enough to the nozzle and to be in any danger.



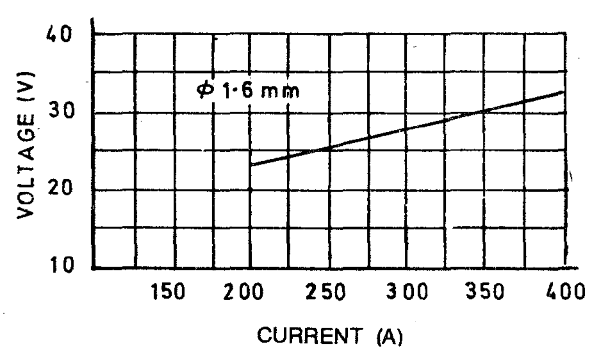
1A 0.8 mm Wire Diameter



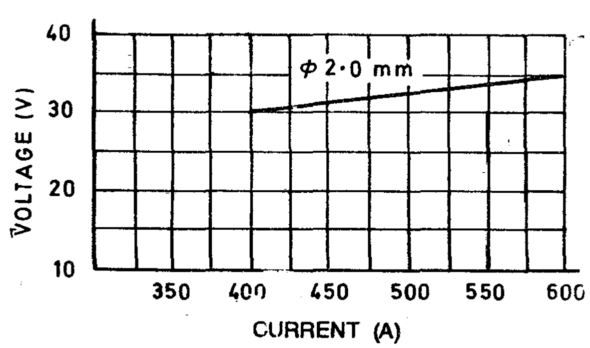
1B 1.0 mm Wire Diameter



1C 1.2 mm Wire Diameter



1D 1.6 mm Wire Diameter



1E 2.0 mm Wire Diameter

FIG. 1 CURRENT-VOLTAGE COMBINATIONS FOR VARIOUS WIRE DIAMETERS

However, a good ventilation of working place is a must.

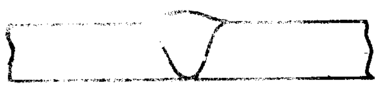
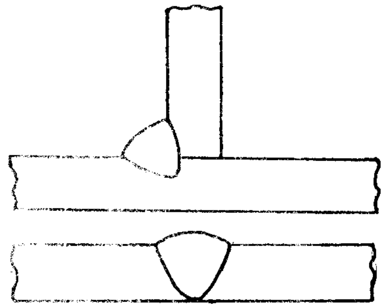
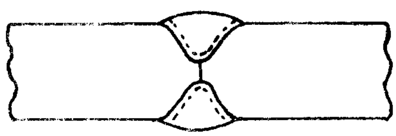
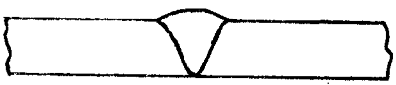
Because of CO_2 welding is an open arc process, which can employ high currents, radiation can be a problem. Excessive ultraviolet radiation on an unprotected eye will give rise to the condition known as 'arc eye', when irritation is set up and the eyes becomes painful and watery. There is intense photophobia and the acute symptoms may last for one or two days. Although no permanent damage is done, accidental exposure should be avoided by proper screening of personnel working near welding position.

Ultraviolet radiation can also produce severe sunburn effects on exposed areas of the face, neck and arms. This can happen not only to the welder but to other personnel who may be working some distance from welding areas where high current arcs are being used. Local screening of the arc zone is suggested for preventing sunburn effects. Reflective surfaces around the area should be kept to a minimum.

In a properly ventilated shop, CO_2 welding causes no ill effect on the welders who are regularly employed for it.

Table 6 Weld Defects and Their Causes

(*Clause* 15)

Weld Defects		Causes
Porosity		Insufficient S1, Mn in wire, Insufficient CO_2 shielding because of; a) low flow rate b) frozen valve c) clogged nozzle d) draughts
Cracks		Impure CO_2 gas Dirty work-grease, paint, scale rust i) Weld bead too small ii) Weld too deep, internal bead ratio greater than 12:1 iii) High sulphur, low manganese, faster cooling rate iv) Restrained joint
Undercutting		Travel speed too high; Backing bar groove too deep: Current too low for speed Wrong torch angle
Lack of penetration		Current too low-setting wrong Wire feed fluctuating Joint preparation too narrow Angle too small Gap too small Wire-extension fluctuating
Lack of fusion		Uneven torch manipulation Insufficient inductance (short circuiting arc) Voltage too low
Non-metallic inclusion		Technique-too wide a weave Current too low Irregular weld shape
Spatter-on work on nozzle in weld		Voltage too high Insufficient inductance Insufficient nozzle cleaning
Irregular weld shape		Excessive electrode extension Wire temper excessive No straightening rolls Current too high for voltage Travel speed too slow

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Review of Indian Standards

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